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Window Regulator

Field of Invention

[0001] The invention generally relates to the field of window regulators, and more particularly to window regulators for automotive applications.

Background of Invention

[0002] One of the design objectives for window regulating systems, particularly in automotive applications where the regulator controls the vehicle window, is to optimize the operating torque by maximizing the number of crank turns to the limit provided for by specification. In automotive applications, the maximum number of permissible crank turns is generally limited in manual applications to about 6 - 6.5 turns. Reducing the operating torque reduces the amount of power or manual effort required to raise the window.

[0003] Conventionally, operating torque can be reduced by reducing the diameter of the drum which connects the crank to the cable(s) attached to the lift plate. The problem with this solution is that the cable is subject to higher stress because it is wrapped around a smaller diameter. In addition, decreasing the diameter of the drum will increase the number of turns, resulting in a wider drum. This could result in packaging problems since the width of the drum and drum housing must fit within a confined space defined between the inner and outer panels of a vehicle door. In addition, increasing the number of drum turns increases the possibility of ratcheting (i.e., noise) resulting from the cable rubbing against the grooves in the drum, particularly since the cable is routed at a greater angle between its intake position entering the drum housing and the outermost turns of the drum.

[0004] An alternative approach to reducing operating torque is to employ a gear reduction system in the drum housing. The problem with this

solution is that the extraneous gears typically increase the width of the drum housing, leading to the packaging constraints discussed above. Another problem with gear reduction systems is that they typically require tight tolerances, driving up costs, and backlash is a persistent problem in such systems.

[0005] An alternative solution of preferably low cost is desired in order to optimize torque in window regulating systems.

Summary of Invention

[0006] In general, the invention employs a pulley 'block and tackle' principle in order to obtain a mechanical advantage for reducing operating torque requirements.

[0007] According to one aspect of the invention, a window regulator assembly is provided which has a rail on which a lift plate is mounted to slide therealong. The lift plate is configured to mountingly receive a window thereto. A lift pulley is rotatably mounted on the lift plate. A first guide pulley and a second guide pulley are respectively mounted near first and second ends of the rail. The assembly has at least one cable that has a first end anchored near the first end of the rail and wound about the lift pulley and thence routed about the first guide pulley to operatively engage a multi-turn cable-guiding rotatable drum, and a second end anchored near the second end of the rail and wound about the lift pulley and thence routed about the second guide pulley to operatively engage the drum. Operative movement of the drum in a first sense tensions the at least one cable to move the lift plate towards the first end of the rail, and operative movement of the drum in a second sense, opposite the first sense, tensions the at least one cable to move the lift plate towards the second end of the rail.

[0008] The window regulator preferably employs two cables anchored to the drum and disposed to wind around the drum. The first cable is fixed near the first end of the rail, thence wound around the lift pulley to the first

guide pulley, and thence routed to the drum. The second cable is fixed near the second end of the rail, thence wound around the lift pulley to the second guide pulley, and thence routed to the drum. The motive power for rotating the drum may be provided via a hand crank or an electric actuator such as a motor.

[0009] According to another aspect of the invention, a dual-rail window regulator assembly is provided having first and second rails; first and second lift plates respectively slidably mounted to the first and second rails; first and second lift pulleys respectively slidably mounted to the first and second lift plates; and first and second guide pulleys (140A, 140B) respectively mounted near first and second ends of the first and second rails. At least one cable has a first end anchored near the first rail end and wound about the first lift pulley of the first rail and thence routed about the first guide pulley to operatively engage a rotatable multi-turn, cable-guiding drum. A second end of the at least one cable is anchored near the second rail end and wound about the second lift pulley of the second rail and thence routed about the second guide pulley to operatively engage the drum. Additional means, such as a third cable, interconnect the first and second lift plates. The operative movement of the drum in a first sense tensions the at least one cable to move the first and second lift plates towards the first rail end, and operative movement of the drum in a second sense, opposite the first sense, tensions the at least one cable to move each lift plate towards the second rail end.

[0010] According to another, more general aspect of the invention, a window regulator assembly is provided which includes at least one rail, a lift plate slidably mounted on each rail, and a lift pulley mounted to each lift plate. A first guide pulley is mounted near a first end of the at least one rail, which represents a one end of window travel (e.g., the open position). A second guide pulley is mounted near an opposing second end of the at least one rail, which represents another end of window travel (e.g., the closed position). A cable, which may be provided in one or more segments, has a first end anchored near the first rail end and wound about the lift pulley associated with

the rail presenting said first rail end and thence routed about the first guide pulley. A second end of the cable is anchored near the second rail end and wound about the lift pulley associated with the rail presenting said second rail end and thence routed about the second guide pulley. A drive means is provided for tensioning and translating the cable. Actuating the drive means in a first sense tensions the cable to move each lift plate towards the first rail end, and actuating the drive means in a second sense, opposite the first sense, tensions the cable to move each lift plate towards the second rail end.

[0011] The drive means may include a multi-turn cable-guiding drum powered by a hand crank or motor. Alternatively, at least one of the guide pulleys may be connected to a hand crank or motor and include a multi-turn cable guide for winding and unwinding the cable thereon, thus reducing the part count.

[0012] Another broad aspect of the invention relates to replacing a guide pulley in a window regulating system with a drive pulley having a multi-turn cable guide for winding and unwinding a cable thereon, and driving such a pulley with an external drive.

Brief Description of Drawings

[0013] The foregoing and other aspects of the invention will become more apparent from the following description of illustrative embodiments thereof and the accompanying drawings, which illustrate, by way of example, the principles of the invention. In the drawings:

[0014] Fig. 1 is a perspective view of one side of a window regulator according to a first exemplary embodiment;

[0015] Fig. 2 is a perspective view of the opposite side of the window regulator shown in Fig. 1;

[0016] Fig. 2B is an isolated cross-sectional view of a rivet pulley employed in the window regulator shown in Fig. 1;

[0017] Fig. 3 is a schematic diagram of a pulley system, shown in isolation, which is employed in the window regulator shown in Fig. 1 to provide a 2:1 mechanical advantage;

[0018] Fig. 4 is an isolated view of a cable-winding drum employed in the window regulator shown in Fig. 1;

[0019] Figs. 5A and 5B are schematic diagrams of a pulley system according to an alternative embodiment which yields a 4:1 mechanical advantage;

[0020] Fig. 6 is a schematic diagram of a window regulator according to a second exemplary embodiment, which employs dual rails and dual lift plates;

[0021] Fig. 7 is a schematic diagram of a window regulator according to a third exemplary embodiment, which employs conduit-less cables;

[0022] Fig. 7B is cross-sectional view of an anchor, taken in isolation, employed in the window regulator shown in Fig. 7; and

[0023] Fig. 8 is a schematic diagram of a window regulator according to a third exemplary embodiment, which has a reduced part count.

Detailed Description of Preferred Embodiments

[0024] Figs. 1 and 2 show a window regulator 10 according to a first exemplary embodiment. The regulator 10 comprises a rail assembly 12 which is mountable to the vehicle door structure via integrally formed brackets 14. A lift plate 16 including a plastic guide 18 is mounted to the rail assembly 12. More particularly, the guide 18 includes slotted tabs 20 which slidingly ride along flanges 22 formed along the edges of the rail assembly 12. The lift

plate 16 includes rubber-tipped clamps 24 for mounting the vehicle window (not shown) thereto. Stops 26 define the upper and lower limits of travel for the lift plate 16, and hence the maximum distance traversed by the vehicle window.

[0025] The lift plate 16 is regulated by a pulley system 30, shown in isolation in Fig. 3, which comprises an upper cable 32a and a lower cable 32b. The upper cable 32a is anchored to the top of the rail assembly 12 by an anchor 34a. The upper cable 32a is routed around a pulley rivet or lift pulley 36. The lift pulley 36 is preferably rotatably mounted to the lift plate 16 and features two independent (i.e., non-spiraling) grooves 38a, 38b, as detailed in Fig. 2B. The upper cable 32a is routed around one of the grooves 38a, 38b and back up to an upper guide pulley 40a which is rotatably mounted to the top of the rail assembly 20. From the guide pulley 40a the upper cable 32a is routed through a first conduit 42a and attached to a crank assembly 44. The crank assembly 44 includes a multi-turn cable-guiding drum 445 (not explicitly shown in Fig. 1 & 2) as well known in the art *per se* which is mounted in the housing 45 of the assembly 44. The upper cable 32a is anchored to the drum and, depending on whether or not the limit of travel has been reached, partially wound around the drum.

[0026] The conduit 42a is mounted to the rail assembly 12 by a conduit socket 46a mounted in a receptacle 48a formed in the rail assembly. Another conduit socket 50a is mounted to an intake tube 52a of the housing 45, and a torsion spring 54a is provided to maintain tension on the upper cable 32a.

[0027] The lower cable 32b is routed in a similar manner. The lower cable 32b is anchored to the bottom of the rail assembly 12 by an anchor 34b and routed around the other of the grooves 38a, 38b of the lift pulley 36. From the lift pulley 36 the lower cable 32b is routed around back down to lower guide pulley 40b which is fixed to the bottom of the rail assembly 20. From the guide pulley 40b the lower cable 32b is routed through a second

conduit 42b and attached to the multi-turn cable-guiding drum of the crank assembly 44.

[0028] The second conduit 42b is mounted to the rail assembly 12 by a second conduit socket 46b mounted in a second receptacle 48a formed in the rail assembly. A second conduit socket 50b is mounted to a second intake tube 52b of the housing 45, and a second torsion spring 54b is provided to maintain tension on the lower cable 32b.

[0029] A handle 60 (shown in phantom) is attached to the crank assembly 44. Rotating the handle 60 causes the cable-guiding drum 445, shown in isolation in Fig. 4, to rotate. The drum 445 converts rotational motion to linear motion so as the drum 445 rotates, the cables 32a, 32b which are wound around the drum, are translated. More particularly, as the drum 445 rotates, one of the upper and lower cables 32a, 32b spools onto the drum while the other cable correspondingly spools off the drum, i.e., one cable winds onto the drum while another cable winds off the drum.

[0030] As the drum rotates, the length L_u of one of the cables 32a, 32b as measured along the rail flange 22 increases with a corresponding decrease in the length L_l of the other cable as measured along the rail flange. In conjunction, the lift pulley 36 travels up or down depending on which cable increases its length along the rail. Note that as a result of the pulley system, the lift pulley 36, and hence the vehicle window, travels at substantially half the speed of the cables, yielding a 2:1 mechanical advantage and thus a 2:1 reduction in motive torque requirements. This is shown also in the exaggerated schematic diagram of Fig. 3.

[0031] It is desirable to have both upper and lower cables 32a, 32b wrapped around the lift pulley 36 from opposing directions in a symmetrical arrangement. Note that one of the cables, e.g., cable 32a, is routed in a 'block and tackle' arrangement and, being under tension, presents a force acting upwards on the pulley rivet 36 and lift plate 16. The other cable, e.g.,

cable 32b, is also routed in a block and tackle arrangement and, being under tension, presents a force acting downwardly on the pulley rivet 36 and lift plate 16. The upward and downward forces are preferably selected so as to be substantially equal.

[0032] The pulley block and tackle principle can be applied to yield other mechanical advantage ratios. For example, Fig. 5A shows, in schematic form, an alternative embodiment which provides a 4:1 mechanical advantage. Fig. 5B is a perspective view of the lift pulley of this embodiment, taken in isolation, showing the cable routing about the lift pulley.

[0033] Fig. 6 shows, in schematic form, a second exemplary embodiment of a window regulator 100 which employs two rails 112A and 112B having two lifter plates 116A, 116B respectively glidingly connected thereto. First and second cables 132A and 132B are attached to and spool to/from a multi-turn cable-guiding drum (not shown) of a crank assembly 144. In this embodiment, the first cable 132A, which is anchored to the top of the first rail 112A at 134A, extends around a lift plate pulley 136A rotatably mounted to lift plate 116A, and thence around a pulley 140A rotatably mounted to the top of rail 112A to the crank assembly 144. In a similar manner, the second cable 132A is anchored to the bottom of the second rail 112B at 134B, extends around a lift plate pulley 136B rotatably mounted to lift plate 116B, and thence around a pulley 140B rotatably mounted to the bottom of rail 112B to the crank assembly 144. Thus, the pulley rivet 36 of the first embodiment is essentially replaced by the two pulleys 136A, 136B. A third cable 132C wrapped around pulleys 170A, 170B respectively mounted to rails 112A, 112B interconnects the two lift plates 116A, 116B together. In operation, as the crank assembly 144 is rotated, the lifter plates 116A, 116B and hence the window travels at half the speed of cables 132A, 132B yielding a 2:1 mechanical advantage.

[0034] It will be understood that while the embodiments described above have employed at least two cables, a single cable could be wound

around the drum and used to translate the pulley rivet or lifter plate(s). In addition, while the embodiments discussed above have shown a manually activated crank assembly, it will be understood that other drive means can be provided for tensioning and translating the cable, such as a motor operatively coupled to a multi-turn drum cable or other electro-mechanical actuator providing the motive torque for actuating the regulator.

[0035] Furthermore, while the cable shown in the embodiments discussed above is sheathed in conduits, it will be appreciated that a conduit-less window regulator system is also contemplated. For example, Fig. 7 shows a window regulator system 210 having a rail 212, a lift plate 216 mounted to slide along the rail 212; a lift pulley 236 mounted to the lift plate 216; a cable 230; and first and second guide pulleys 240a, 240b respectively mounted near first and second ends of the rail 212. The cable 230 has a first end anchored (via anchor 234a) near the first end of the rail and is wound about the lift pulley 236 and thence routed about the first guide pulley 240a. A second end of the cable 230 is anchored (via anchor 234b) near the second end of the rail and wound about the lift pulley 236 and thence routed about the second guide pulley 240b. Fig. 7B is a cross-sectional view of anchor 234 which includes a socket 248 mounted in an aperture of the rail. The cable 230 has a nipple 250 mounted at the end thereof. The nipple enables the cable to receive tensioning forces provided by a spring 248. No cable conduits are employed.

[0036] The cable 230 extends between the first and second guide pulleys and is preferably provided in two separate segments, 230a and 230b, each of which is anchored to or otherwise connected to a cable drive means, such as a motor-driven cable guiding drum 244. Actuation of the drive means in a first sense tensions the cable to move the lift plate towards the first end of the rail, and actuation of the drive means in a second sense, opposite the first sense, tensions the cable to move the lift plate towards the second end of the rail. Note that in this embodiment, each cable segment is wrapped around the

pulleys or drum in one direction only, thus eliminating "reverse bending" of the cable and the risk of premature fatigue.

[0037] It should also be appreciated that one of the pulleys employed in any of the above-described embodiments can be replaced with a cable-guiding drum, i.e., one of the pulleys can be a drive pulley. For example, Fig. 8 shows a conduit-less window regulator system 310 having a rail 312, a lift plate 316 mounted to slide along the rail 312; a lift pulley 336 mounted to the lift plate 316; a cable 330; and first and second guide pulleys 340a, 340b respectively mounted near first and second ends of the rail 312. The cable 330 has a first end anchored (via anchor 334a) near the first end of the rail and is wound about the lift pulley 336 and thence routed about the first guide pulley 340a. A second end of the cable 330 is anchored (via anchor 334b) near the second end of the rail and wound about the lift pulley 336 and thence routed about the second guide pulley 340b. The cable 330 extends linearly between the first and second guide pulleys. In this embodiment, the second pulley has a multi-turn spiraling groove on the outside diameter thereof and is drivingly connected to a motor, thus providing an alternative drive means for translating the cable. Actuation of the drive means in a first sense tensions the cable to move the lift plate towards the first end of the rail, and actuation of the drive means in a second sense, opposite the first sense, tensions the cable to move the lift plate towards the second end of the rail. The principle advantages provided by this embodiment are a reduced part count and a very narrow lateral profile.

[0038] Those skilled in the art will appreciate that a variety of other modifications may be made to the embodiments disclosed herein without departing from the spirit of the invention.